MECHANICAL PROPERTIES OF CALCIFIED BLOOD VESSELS WALLS

Magdalena Kobielarz

Division of Biomedical Engineering and Experimental Mechanics, Institute of Machine Design and Operation, Faculty of Mechanical Engineering, Wroclaw University of Technology, Poland; Regional Specialist Hospital in Wroclaw, Research and Development Centre, Poland

Introduction

Blood vessels walls are the predisposed sites for calcifications. Deposition of minerals within blood vessels walls is one of the most striking signs of atherosclerosis. Mechanism leading to the formation of vascular mineral deposition is complex and remains unclear.

Insufficient information has been published regarding the mechanical properties of calcified blood vessels walls. To the best author knowledge, only Marra [2006] and Kot [2011] have presented some information about mechanical properties of human mineralized walls of aorta. This is an important issue, because understanding the risks associated with presence calcified regions within blood vessel walls is crucial for development new treatment and diagnosis methods.

Methods

The mechanical properties were determined for the human calcified major blood vessels (thoracic and abdominal aortas) (n=7) obtained post-mortem. The mechanical properties were evaluated by using the instrumented indentation method. In this study a Berkovich indenter and a MCT-CSM machine were used. A typical loading-unloading curve obtained from the indentation of samples under 5mN maximum load was analysed and the hardness (H_{IT}) and the elastic modulus (E_{IT}) of the sample were determined. In this study, Poisson's ratio of calcified aorta was set to 0.3 and the diamond properties were: E_d=1140GPa and v_d=0.07.

Two orthogonal directions (I – parallel and II – perpendicular directions to sample thickness) of the calcified aorta were selected for micromechanical measurements. Were also performed an analysis of the mechanical properties of the polished sections made of calcified blood vessels walls in steps of approximately 50µm (gradient analysis).

Results

The mechanical properties obtained for calcified aorta in both analysed directions do not differ from each other at a statistically significant level and amount to respectively for I and II directions : approximately 700 and 720 MPa for the hardness, and 21 and 24 GPa for the elastic modulus. Gradient analysis revealed significant differences in the values of both the hardness and the elastic modulus depending on the indentation location. The highest values were obtained for the outer area of calcification. Values were decreased with a distance from the edge of the calcification (to approach to the centre of calcification) and then were increased with approaching to the opposite end of the area of mineralization. Obtained mechanical properties in individual areas differ twofold (at average level).

Discussion

It was demonstrated that mechanical parameters - hardness and elastic modulus - are comparable in both analysed directions at a statistically significant level, which indicates isotropic properties of area of mineralization. A similar conclusion about calcium deposit isotropy can be made from the results presented by Marra [2006] and Kot [2011]. The mechanical properties of the polished sections revealed significant differences, what could be conditioned by structural composition of blood vessels walls under mineralization process [Kobielarz, 2012].

References

Marra et al, Acta Biomater, 2:515-520, 2006.

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